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April 17, 2012

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Written *Ex Parte* Presentation
WT Docket No. 07-293; IB Docket No. 95-91

Dear Ms. Dortch:

Sirius XM Radio Inc. ("Sirius XM") herein provides additional technical information describing the potential for WCS mobile wireless operations to cause harmful interference to satellite radio services under the rules adopted in the 2010 *Second Report and Order* in this proceeding.[1] As described in the two attachments, large scale deployment of WCS mobile systems would cause pervasive harmful interference to satellite radio consumers, both from WCS uplink and downlink operations.

The first attachment (*"Analysis of the WCS Coalition's January 26, 2012 Interference Simulation"*) provides further documentation challenging the WCS Coalition's recent computer simulation of uplink interference that WCS licensees may create.[2] As Sirius XM previously explained,[3] the Coalition's simulation suffers from multiple methodological shortcomings limiting its value as a representation of the actual interference potential of a real-life WCS deployment. As discussed more fully in the attachment, the model: (1) understates the potential impact of eliminating the power spectral density ("PSD") requirement by limiting WCS mobile

[1] Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band, WT Docket No. 07-293, Report and Order, Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, IB Docket No. 95-91, Second Report and Order, 25 FCC Rcd 11710 (2010) ("2010 Order").

[2] Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed January 26, 2012).

[3] Letter from James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio Inc. and Terrence R. Smith, Corporate Vice President and Chief Engineering Officer, Sirius XM Radio Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed February 7, 2012).

uplink power to 100 mW – well below the maximum allowed – and failing to test the worst-case impact of eliminating this requirement, (2) assumes artificially small cell ranges, (3) ignores the effects of possible WCS transmissions over multiple aggregated WCS spectrum blocks, (4) relies on several technology-specific assumptions, and (5) contains various other design flaws related to technical parameters. Given these shortcomings, the WCS Coalition has evaluated the interference potential of only a single theoretical WCS deployment that is heavily constrained. Lacking broad application to WCS networks and real-live interference scenarios, this paper has no value in the Commission's reconsideration proceeding.

The Coalition's simulation also exposes the elevated risk for downlink interference to satellite radio receivers due to the large number of WCS base stations that would be required under the simulation's assumptions. To address this issue, the second attachment to this letter (*"Impact of WCS Downlink Interference"*) provides further analysis of the potential for downlink interference to satellite radio consumers caused by WCS base stations. The document first discusses the interference potential of different types of WCS deployments, for example, contrasting GoGo, Inc.'s proposed air-to-ground WCS deployment with a traditional terrestrial cellular architecture. Next, the study provides the results of a new simulation of the downlink interference that widespread WCS terrestrial cellular deployment could cause to satellite radio consumers. Sirius XM prepared this simulation based on a Las Vegas, Nevada WCS deployment that NextWave proposed in 2007. Applying the interference tolerances of satellite radio receivers that Sirius XM has previously submitted into the record,[4] this simulation predicts that under real world conditions, a dense cellular-type deployment in the WCS band could cause significant downlink interference to satellite radio consumers in large portions of the Las Vegas area. The results of this simulation again highlight the need for rules that would help prevent this type of interference, such as the ground level power flux density limits that Sirius XM has previously advocated.[5]

Taken together, these technical analyses further demonstrate the real and substantial risk of harmful interference to satellite radio consumers posed by WCS mobile broadband operations under the Commission's 2010 rules. Granting the WCS Coalition's request for additional relief from the few technical protections in place would severely aggravate these risks with little likelihood that any interference could be remediated without harming satellite radio customers.

[4] See Comments of Sirius Satellite Radio Inc., Exhibit C, WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610 (filed Feb. 14, 2008). See also Letter from James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio Inc. and Terrence R. Smith, Corporate Vice President and Chief Engineering Officer, Sirius XM Radio Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed March 30, 2012).

[5] See Petition for Partial Reconsideration and Clarification of Sirius XM Radio Inc., WT Docket No. 07-293, (filed Sept. 1, 2010) at 16 – 18.

The Commission should reject the WCS Coalition's request and instead, grant Sirius XM's Petition for Partial Reconsideration and Clarification for the reasons set forth therein and in related pleadings.[6]

Sincerely,

/s/ James S. Blitz
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Attachments

Analysis of the WCS Coalition's January 26, 2012 Interference Simulation
Impact of WCS Downlink Interference

6 Petition for Partial Reconsideration and Clarification of Sirius XM Radio Inc., WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610 (filed Sept. 1, 2010).

Analysis of the WCS Coalition's January 26, 2012 Interference Simulation

Sirius XM Radio Inc.
April 17, 2012

I. Summary

On January 26, 2012, the WCS Coalition filed a written *ex parte* presentation including an interference simulation purporting to justify its request that the Commission eliminate the 50 mW/MHz power spectral density ("PSD")[1] limit on WCS mobile devices.[2] Sirius XM has previously noted that this simulation suffers from significant methodological deficiencies and should be disregarded.[3] This technical appendix expands on Sirius XM's analysis.

Specifically, the WCS Coalition's simulation is flawed because it contains faulty assumptions and models only a single, limited use scenario that presents nearly a "best-case" interference environment. Other deficiencies of the computer model include: (1) the simulation limited WCS mobile device uplink power to 100 mW, which is well below the maximum allowed so the worst-case impact of eliminating the PSD requirement was not tested, (2) the simulation ignored the increased interference effects of 10 MHz channel bonding, (3) the simulation relied on technology-specific assumptions and arguments, and (4) the model had various other design flaws, including using low uplink burst rates, using small cell sizes, and failing to use a mutually-agreed interference coordination criteria. Due to these limitations, the Coalition's simulation does not justify revising the PSD limits that the Commission imposed on WCS mobile operations in 2010 to protect satellite radio.

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[1] The Commission established the current PSD limit based on real life field test data and no data has been filed to justify any relaxation. Note that in the Ashburn, VA field demonstrations, the WCS Coalition avoided transmitting near the SDARS band by using a guard band of at least 2.5 MHz, which is one way that demonstration artificially reduced the interference potential to satellite radio. *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 at 5-6 (filed May 18, 2009); *see also* Comments of Sirius XM Radio Inc. at 18-20, WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610 (filed Apr. 23, 2010) ("Sirius XM Comments"). Even this simple example shows that allowing more power near the SDARS band by revising or eliminating the PSD requirement would increase the potential for interference from WCS.

[2] Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed January 26, 2012) ("WCS Coalition January 26 Letter").

[3] Letter from James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio Inc. and Terrence R. Smith, Corporate Vice President and Chief Engineering Officer, Sirius XM Radio Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed February 7, 2012).

More recently, the WCS Coalition submitted a test report prepared by ATECS, LLC ("ATECS"),[4] which presents data collected from a 700 MHz LTE system in a very brief time period using specific test conditions.[5] ATECS tested an LTE mobile device transmitting with power levels below the 50 mW/MHz PSD limit during most of the limited test window at the chosen test location, and claimed any "excursions" from this limit occurred for durations shorter than the maximum SDARS receive buffer time period of 4 seconds.[6] In this technical appendix, Sirius XM identifies the shortcomings of this latest filing, including the WCS Coalition's fundamental misconception about the ability of satellite radio receiver buffers to overcome WCS interference.

Based upon the analysis in this study and in other materials filed in this docket, Sirius XM recommends that the Commission:

- Retain the current PSD limit at 50 mW per 1 MHz; and
- Reduce the emission limits by 10 dB to address the increased interference potential when WCS operators employ channel bonding or where transmissions are made over multiple WCS blocks from the same base station tower.

II. The WCS Coalition Model Does Not Simulate Potential Interference Up to the Allowed Uplink Emission Limits.

The Coalition's model artificially limits the radiated uplink power level to 100 mW (20 dBm) for a 10 MHz wide channel.[7] This is well below the radiated emission limit allowed in the Commission's rules of 250 mW for each of the 5 MHz A and B blocks.[8] Bonding two WCS blocks to make a 10 MHz channel increases the allowed power level to 500 mW. Therefore, the power level that the Coalition simulated by is 7 dB lower than the current limit, falling short of simulating the potential interference by a large margin.

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[4] Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed March 8, 2012) ("ATECS Report"). The ATECS Report is discussed in greater detail in Section VI hereof.

[5] *Id.* at 2.

[6] *Id.*

[7] While the Commission's simulated power level of 100 mW for a 10 MHz channel is in line with Sirius XM's previous interference coordination proposals for 50 mW per 5 MHz levels, there is no reason to believe WCS operators will actually configure their transmitters to these specifications. The model claimed 23 dBm conducted output power with a -3 dBm user terminal antenna gain to result in 20 dBm radiated power. Publicly available industry guidance materials suggest use of higher radiated power levels at 24 dBm; where the transmit power level is defined as 24 dBm and the antenna gain is defined as 0 dB. *See* Motorola, White Paper: "TD-LTE, Exciting Alternative, Global Momentum" (2010) *available at* http://www.tdia.cn/test/en/downloa/20111214.pdf. Additionally, antenna gain levels are typically recommended to be set at 0 dB for simulation purposes. *See* HARRI HOLMA & ANTTI TOSKALA, LTE FOR UMTS, EVOLUTION TO LTE ADVANCED, 267, Wiley Publications, 2011.

[8] See 47 C.F.R. §27.50 (a)(3).

III. The WCS Coalition Model Does Not Simulate Potential Interference from Channel Bonding.

The WCS Coalition's model uses a 10 MHz channel. Sirius XM's April 23, 2010 filing[9] showed that tolerable interference levels decrease roughly by 10 dB for a 10 MHz WCS interferer when compared to the levels measured for a 5 MHz interferer. For example, interference tolerance was measured between -54 to -58 dBm for a 10 MHz channel whereas it was -44 dBm for a 5 MHz A or B block interferer. It is not known whether or how the Coalition's model addressed this issue.[10] Based on the limited information the Coalition provided about its model, it seems not even to address the satellite radio muting levels for the test case simulated in the model, discussing only the periods of time that the mobile unit transmitted at more than the current PSD limit levels, with an artificial power limit at 100 mW. Thus, the Coalition's model does not properly simulate interference to satellite radio both by failing to use the maximum power levels that would be allowed in a channel bonding scenario and by not considering the lower interference impact levels that would occur in this condition.

IV. Heavy Use of Technology-Specific Arguments Limits the Usefulness of the WCS Coalition Model.

The WCS Coalition model is only a technology-specific example that assumes LTE as the technology choice for all WCS networks. However, technology choices evolve over time and options different than LTE are nearly certain to be deployed in some WCS networks. Even now, other WCS deployment examples utilize WiMAX technology,[11] and GoGo recently proposed a CDMA2000-based system.[12] Nearly all of the earlier test results filed in this proceeding assumed WiMAX as the technology choice, consistent with the WCS Coalition's longstanding proposal.[13] Some WCS interests have recently shifted their focus to LTE, but LTE itself will soon have different implementations and will continue to evolve. Moreover, LTE eventually will be replaced with future cellular technologies.[14] As a result of the rapid

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[9] *See* Sirius XM Comments.

[10] A 10 MHz use case was also not demonstrated in the WCS Coalition's Ashburn demo.

[11] *See, e.g.*, Letter from Elizabeth R. Sachs, Counsel to San Diego Gas and Electric, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed Jan. 5, 2012); Petition of AT&T, WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610 (filed Aug. 2, 2010) (discussing wireless broadband use of WCS spectrum).

[12] *See* Letter from Thomas Gutierrez, Counsel to GoGo Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed Jan. 13, 2012).

[13] Letter from Mary N. O'Connor, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed Aug. 4, 2009) ("WCS Coalition Ashburn *Ex Parte*")

[14] Phil Goldstein, *AT&T to Deploy LTE-Advanced in 2013*, FierceWireless, Nov. 8, 2011, http://www.fiercewireless.com/story/att-deploy-lte-advanced-2013/2011-11-08; Sue Marek, *Sprint Will Deploy LTE Advanced in the First Half of 2013*, FierceWireless, Oct. 25, 2011, http://www.fiercewireless.com/story/sprint-will-deploy-lte-advanced-first-half-2013/2011-10-25; Brad

rate of change in wireless broadband technology, multiple and evolving technologies will in fact be used in the WCS bands. Therefore, any modeling or testing must be based on technology-neutral methods.

The Coalition's model also discusses a Frequency Division Duplex (FDD) implementation. However, this model cannot be used to predict the aggregate interference effects from a TDD implementation proposed by Coalition members[15] since the aggregate up/downlink interference conditions are different. Also, no test data has been filed in this docket to justify the model's implementation for the FDD case. By contrast, Sirius XM tested overload and OOBE impacts under real world conditions in a technology-independent approach, providing WCS emission limit recommendations based on data that can be repeated with technology changes in the long term.[16]

V. Other Issues Limit the Usefulness of the Coalition's Model.

Numerous other erroneous parameters and mistaken assumptions in the WCS Coalition model limit its value by causing the simulated uplink emission behavior to vary from the performance that would be expected in an actual WCS system.

- The WCS Coalition indicates that the simulation platform's carrier frequency is centered at 2305 MHz with a channel bandwidth of 10 MHz,[17] meaning the WCS transmission would occur between 2300 MHz and 2310 MHz. The 2300-2305 portion of this carrier is outside of the WCS bands, and farther from the SDARS bands than WCS is allowed to operate. As a result, use of this part of the band makes this simulation entirely inapplicable for WCS/SDARS coordination.
- The implemented traffic simulations are file download and video streaming scenarios, both of which are downlink-intensive applications, requiring very little uplink activity. However, the model does not simulate uplink-intensive applications such as video chat, which would pose a far greater interference threat to satellite radio. Additionally, the model applies the same scenario to all users. This is a significant oversimplification, as real networks include heterogeneous uses, presenting far more complex interference conditions.
- The model assumes only 10 or 15 user devices per cell sector, failing to simulate the characteristics of a loaded cell where higher transmit power levels would be needed to account for the increased interference from other users.[18] Due to this unrealistic network loading presumption, the model may artificially lower simulated transmit power levels.

Molen, *Shocker: Verizon Director Admits to LTE-Advanced Future*, Sept. 15, 2011, http://www.fiercewireless.com/story/sprint-will-deploylte-advanced-first-half-2013/2011-10-25.

[15] Letter from Jennifer M. McCarthy, Vice President, Regulatory Affairs, NextWave Wireless Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (Oct. 13, 2011).

[16] Comments of Sirius XM Radio Inc., Technical Appendix, WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610 (filed April 23, 2010).

[17] WCS Coalition January 26 Letter at 10.

[18] Certain applications support more 200 simultaneous active connections. Verizon Wireless, "LTE: The Future of Mobile Broadband Technology,"

- The model unrealistically assumes that all cells will have a radius of 1 km. In the real world, cell sizes vary greatly, thereby affecting the power of uplink emissions.[19] The greater the range, the more uplink power the user terminal will need to transmit to reach the base station. By limiting the uplink emissions at 100 mW for a cell radius artificially capped at 1 km, the Coalition's model fails to simulate the potential interference cases for coordination purposes.

- The uplink emissions will vary due to micro-area fading conditions, speed, and other effects, none of which appear to be realistically addressed in the model. For example, the channel models are macro-scale fading models that are adequate for capacity calculations, but nothing shows their capability to properly simulate the instantaneous transmission behavior of multiple user terminals in dynamically varying fading channels for interference coordination purposes with satellite radio receivers, especially at long ranges.

- It is unclear how the model simulates out-of-band emissions from individual user terminals as a function of uplink emission levels. This factor will have a significant impact on the overall interference conditions since inadequate modeling can artificially lower the simulated uplink emissions by assuming a lower aggregate system noise floor.

- It is also unclear whether the model assumed that other WCS networks would simultaneously operate in the same region, which would increase the noise floor of the simulated 10 MHz channel and force users to transmit at higher power. Similarly, intermodulation products created from these conditions would further increase the interference to satellite radio. The simulation therefore fails to consider the aggregate effects of out of band emission, overload, and intermodulation interference, which could significantly impact the simulated uplink emission levels.

- The limited information provided about the model does not disclose the simulated power control or scheduling algorithm details that would impact the simulated emission conditions from individual users. The Coalition should therefore provide the full simulation code to allow the Commission and interested parties to evaluate whether the applied algorithms are adequate for interference coordination purposes.

- Finally, the computer model was built without mutually-accepted coordination criteria. Absent such criteria, which would help inform a fundamental understanding of what constitutes interference in this band, no valid conclusions can be drawn about the outputs of the model and its results provide no useful value for interference coordination purposes.

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https://www.lte.vzw.com/Portals/95/docs/LTE%20The%20Future%20of%20Mobile%20Broadband%20Technology.pdf.

[19] Cell sizes of 0.6 km to 3.4 km were reported for urban and suburban environments, and up to 50 km in rural environments. *See* HOLMA & TOSKALA, *supra* note 4, 268. The UMTS forum indicates that the LTE technology can support cell sizes up to 5 Km with full performance, and can reach up to 100 Km with limited performance. UMTS Forum, White Paper: "Towards Global Mobile Broadband: Standardising the Future of Mobile Communications With LTE (Long Term Evolution," February 8, 2008 *available at* http://www.umts-forum.org/component/option,com_docman/task,doc_download/gid,1904/Itemid,214/. *See also* Motorola, White Paper: "TD-LTE, Exciting Alternative, Global Momentum" (2010) *available at* http://www.tdia.cn/test/en/downloa/20111214.pdf.

VI. The ATECS Report.

The WCS Coalition used ATECS to collect empirical data from a commercial LTE system operating at 700 MHz in an undisclosed U.S. city to characterize the uplink resource allocation and uplink transmit power of associated mobile devices. ATECS's task was apparently to collect empirical evidence that LTE mobile devices perform as predicted in the simulation that formed the basis for the WCS Coalition's December 2011 filing and as further discussed in the WCS Coalition January 26 Letter.

Fundamentally, the ATECS Report says:

> [T]he field data collection on a commercial LTE network show that LTE PRB allocations are spread uniformly across the channel bandwidth over short periods of time relevant to the muting mechanisms in an SDARS receiver, and that the typical power levels of an LTE mobile device will be well below the 50 mW/MHz PSD limit in the vast majority of instances . . . LTE can support high uplink data rates without exceeding PSD limit of 50 mW/MHz except in rare instances when the mobile device is operating at the cell edge with full transmit buffer (high uplink data rate) conditions. Even under these circumstances, however, the excursion above the 50 mW/MHz PSD limit occurred for a mere fraction of the SDARS receive buffer time period of 4 seconds.[20]

Based on this paper, the WCS Coalition asserts that any "excursions" above the 50 mW/MHz PSD limit would be "benign" because they occurred for a duration of less than the SDARS receive buffer time period of 4 seconds.[21] Note that ATECS did not corroborate this assertion through direct observation of the performance of a Sirius XM receiver in the presence of LTE uplink device exceeding the 50 mW/MHz PSD limit, which would have enhanced the validity of its test results.

Sirius XM has previously described the role of signal path diversity and receiver buffers in reducing satellite radio service outages due to fading factors such as buildings, hills, trees.[22] However, the idea that fleeting interference caused by emissions generated in the WCS band is mitigated by redundant programming streams is simply incorrect. First, in over 99 percent of the land area of the U.S., Sirius XM's receivers do not receive a signal from any terrestrial repeater. Second, continuous line of sight reception of both satellites signals is not ubiquitous and therefore should not be relied upon for

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[20] ATECS Report at Attachment, page 6.

[21] *Id.* at 2.

[22] *See, e.g.*, Letter from Terrence R. Smith, Senior Vice President, Technology, Sirius XM Radio Inc. and James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed Nov. 13, 2008) ("November 2008 Sirius XM Ex Parte"); Letter from James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed Sept. 8, 2008); Letter from Patrick L. Donnelly, Executive Vice president, General Counsel & Secretary, Sirius Satellite Radio Inc. and James S. Blitz, Vice President, Regulatory Counsel, XM Radio Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket No. 95-91, GEN Docket No. 90-357, RM-8610 (filed Sept. 19, 2007).

interference mitigation. Third, there are differences between the Sirius and XM band plans that must be considered.

Sirius XM has previously explained that the XM Radio platform is delivered by two satellite sub-bands that are further divided into two segments called "ensembles."[23] In delivering service to subscribers, half of XM's audio and data content is transmitted using the upper two satellite carriers (*i.e.*, the "B" ensemble channels 1B and 2B) and the other half is transmitted in the lower two satellite carriers (i.e., the "A" ensemble channels 1A and 2A). Interference to the outer B ensemble channels would wipe out both ensembles, and would result in lost programming and data carried on those channels. Contrary to the Coalition's perceptions, that lost data would not be available over the A ensemble channels.

The ATECS report does not provide sufficient information to derive any meaningful conclusions. Nothing demonstrates that the data taken is representative of the manner in which WCS subscribers will use WCS broadband service when networks are eventually constructed and operating. Nothing describes the types of applications that were performed by the LTE units while being monitored, *e.g.*, whether the devices were simply surfing the internet or conducting a bandwidth-intensive video chat on their LTE-enabled iPad devices. Furthermore, nothing shows whether the network was capacity-limited with multiple user activities occurring in the same sector or was lightly loaded with LTE devices, which would affect the power allocation for each user event.[24] It is not clear whether the test environments adequately demonstrated LTE terminals operating at power levels that would match the power levels allowed in the WCS rules. Finally, the total test period was only 115 seconds taken from all analyzed test locations, which is far too brief of a period to provide reliable, useful data about the operating conditions for all possible deployments.

Despite the issues identified above with the test implementation and its applicability for interference coordination purposes, the ATECS report states that "LTE can support high uplink data rates without exceeding PSD limit of 50 mW/MHz except in rare instances when the mobile device is operating at the cell edge with full transmit buffer (high uplink data rate) conditions." This statement confirms that retaining the current PSD rule, which provides the benefit of minimizing interference to adjacent band users, will not unduly burden WCS network performance.

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[23] *See* November 2008 Sirius XM Ex Parte at 3.

[24] In fact, Figure 8 of the ATECS report shows that the terminal did not need to transmit up to 250w power for a given PRB at any time. As a result, the conditions did not push the user terminal to emit signals at maximum power level and did not represent worst-case conditions.

The Impact of WCS Downlink Interference

Sirius XM Radio Inc.
April 17, 2012

I. Introduction

While uplink interference from mobile devices operating at relatively high power levels could cause signal blocking at the outer range of a WCS base station's coverage area, downlink interference from a base station can create static dead zones at distances closer to the base station – the dual interference threat to SDARs service. The WCS Coalition's recent computer simulation illustrates a dense terrestrial cellular network deployment with a base station radius of 1 km (2 km separation between each base station).[1] Such a deployment could cause significant downlink interference, severely degrading satellite radio reception. This paper analyzes the potential impacts of downlink interference in detail, in the context of various network deployment examples.

The recent *ex parte* filing by GoGo Inc. illustrates how different network architectures can significantly alter the potential for a WCS network to create downlink interference.[2] Assuming a -40 dBm interference impact threshold, GoGo indicated that satellite radio consumer receivers could be impacted by downlink interference up to 0.5 km (or 0.3 miles) from its WCS air-to-ground base stations.[3] However, Sirius XM has stated that satellite radio receivers actually have interference tolerance levels of -55 dBm for the 5 MHz C and D blocks and -44 dBm for the 5 MHz A and B blocks.[4] Channel bonding—for example to create 10 MHz transmission channels—can significantly worsen the interference conditions by reducing the tolerance levels on the order of 10 dB.[5] Using the correct interference level of -55 dBm as the tolerance threshold and criteria in the C and D blocks (where GoGo

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1 Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 at 10 (filed January 26, 2012) ("WCS Coalition January 26 Letter").

2 *See* Letter from Thomas Gutierrez, Counsel to GoGo Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, IB Docket No. 95-91 (filed Jan. 13, 2012) ("GoGo Letter").

3 *Id.* at 12. This analysis assumes GoGo may transmit from its base station at power levels close to the levels allowed in an individual (5 MHz) A and B block at 2000 W and 4000 W, respectively.

4 The SDARS receiver noise floor is -113 dBm per 4 MHz, whereas GoGo assumed -100 dBm. *See* Comments of Sirius Satellite Radio Inc., WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610, Appendix 1 at A6 (filed Feb. 14, 2008).

5 These parameters were tested under real world satellite radio operating conditions in technology-independent and dependent approaches, assuming that both satellite links are muted from WCS interference, thereby eliminating any benefit of satellite diversity or time buffers by fully impacting all satellite signals. *See* Comments of Sirius XM Radio Inc., WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610, Technical Appendix at 8 (filed Apr. 23, 2010) ("April 23, 2010 Technical Appendix").

proposes to deploy its service) suggests the actual zone of interference caused to satellite radio consumer reception would be significantly larger.

Even so, GoGo's air-to-ground communications service is markedly distinct from terrestrial cellular service in terms of the vertical tilt of the base station antenna and the size of the eventual network. In GoGo's case, the base station transmit antenna is aimed above the horizon to provide a wireless link for the aviation services. In contrast, typical terrestrial cellular base station antennae are aimed at or below the horizon so as to provide blanket coverage to users on the ground. Because of this fundamental difference in system design, terrestrial cellular base stations will likely create much wider interference zones for satellite radio consumers than the 0.5 km interference zone radius GoGo assumed for its own base stations, without even taking into account the actual interference thresholds. The interference situation could be even more complex for TDD or FDD systems that may be deployed in the WCS band. In such systems, downlink interference to satellite radio reception at the inner range of the base station coverage area would be accompanied by uplink interference in the same band caused by user equipment at the outer range, or various WCS bands would create different types of interference impact to satellite radio reception. As a result, nearly the entire coverage area could be prone to interference.

Further distinguishing the two service models, unlike most of GoGo's base station locations, terrestrial cellular network base stations such in the WCS Coalition's model are typically located at dense commuter traffic zones where large concentrations of Sirius XM customers typically receive satellite radio transmissions. Such static downlink interference would impair satellite radio service reception for both moving and stationary vehicles. The impact of this type of interference would be particularly noticeable when the satellite radio receiver's vehicle is stopped at a street light or moving slowly in heavy traffic for an extended period of time within the interference zone from a WCS base station.

Another factor making terrestrial cellular-type deployments a more significant source of potential interference is the large number of cellular base stations that may be required: tens of thousands would apparently need to be deployed nationwide to cover dense traffic areas. This ubiquity creates a much greater risk for frequent and widespread interference than the more limited interference impact from some other proposed services, such as GoGo, that would require fewer sites (however, even in this case, each site would create a dead zone for satellite radio service).

We discuss a cellular network deployment example below, to demonstrate Sirius XM's concerns about the potential WCS downlink interference that would result from the emission limits in the current rules, using a similar cellular deployment model to the one suggested in the Coalition's recent filing.

II. WCS Downlink Interference Analysis

The terrestrial cellular network example used in this analysis is modeled on information that NextWave provided to Sirius and XM in 2007 concerning a potential deployment in Las Vegas, Nevada. At the time NextWave was apparently planning to deploy a WiMAX system in the Las Vegas market and had determined actual site locations and heights. While not using the same number of sites or site locations, a similar network arrangement has been used in this analysis to model the interference potentials from such networks. Figure 1 shows the analyzed network layout. Our model assumes that 159 base stations would be deployed in the Las Vegas market. The average base station distance between adjacent sites is nearly 2 km[6] with individual separation distances ranging from 1.13 km to 3.21 km. Similarly, the average height above ground level for an antenna is 17.6 m (individual heights range from 12.2 to 30.5 m). In this real-world model, the generated base station coverage is not uniform as the Coalition simulated in its theoretical model, but rather simulates a more realistic interference scenario.[7]

Note that in this deployment example, the cellular base stations are built on or around dense traffic areas. As a result, the WCS signal hot spots overlap with major roads that are also likely to have dense satellite radio usage.

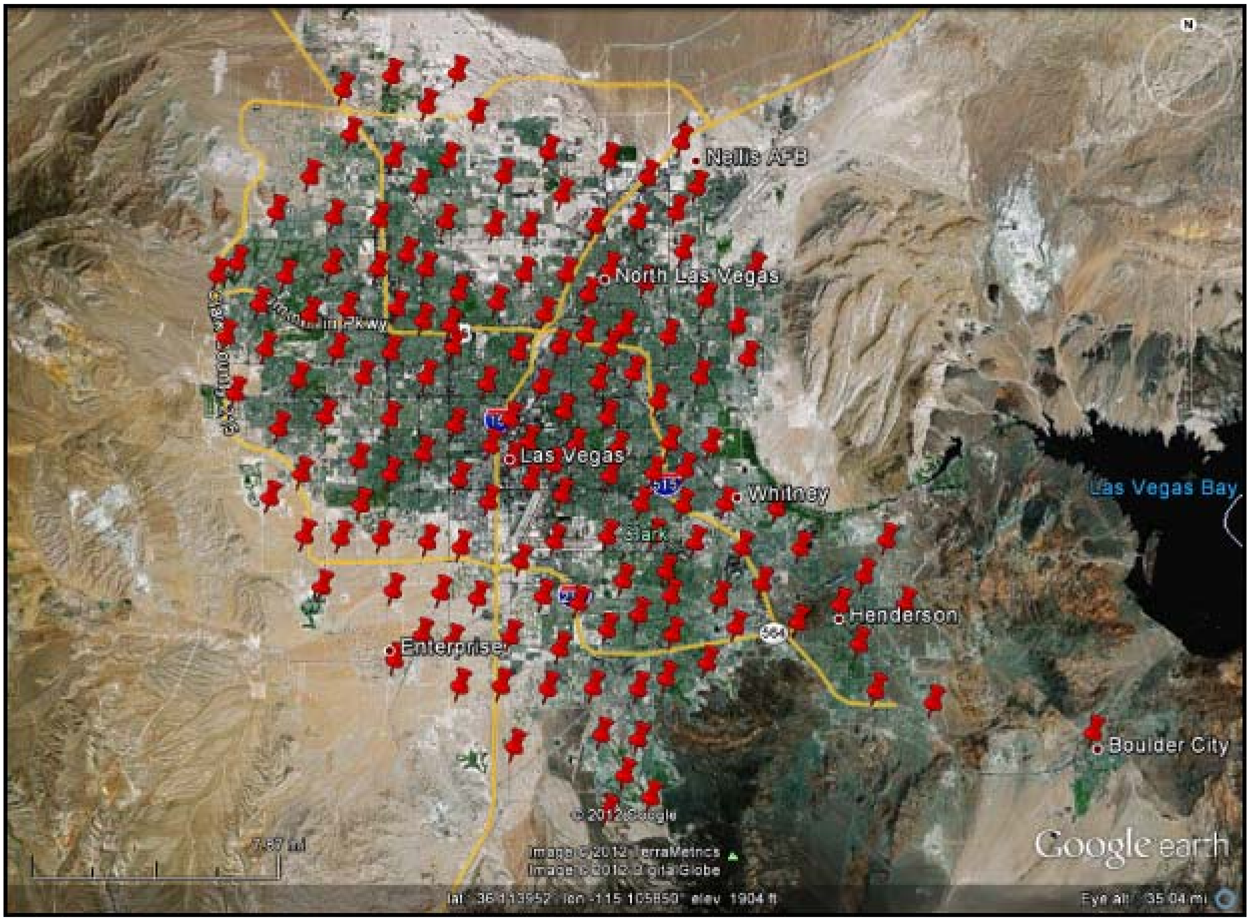

Figure 1: Example cellular network base station deployment in Las Vegas, NV

In the following analysis, the base station signal coverage is considered in relation to the levels that would impact satellite radio reception to predict the expected impact of WCS base station interference on satellite signal reception.

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6 This is similar to the WCS Coalition's recent simulation, which assumed base station radii of 1 km. *See* WCS Coalition January 26 Letter at 10.

7 The Coalition's computer model assumed a rigid 1 km site coverage radius for all sites. A proper analysis method would evaluate the impact at the allowed emission limits for various and complex real life deployment scenarios, not just with a simple and rigid simulation case that caps the base station coverage area size and the user terminal output power levels.

A. Model description

The RF system modeling was produced using EDX Signal Pro®, the advanced radio network planning software that is used to predict coverage and design the actual Sirius XM repeater network. EDX Signal Pro uses site parameters (location, antenna height AGL, antenna pattern, transmit power, frequency, etc.), to model signal propagation, considering terrain and ground clutter to calculate received power at points on a study grid or map.

Two different TIL-TEK Omni-directional antenna patterns were used in different scenarios to model the example WCS cellular deployment. In the first scenario representing a typical cellular base station, all WCS sites were modeled using the TA-2350-DAB antenna with 2° electrical down tilt. In a second scenario, the TA-2350-DAB-6 with 6° electrical down tilt was modeled at every WCS site for comparison. The Sirius XM system was also modeled using the specific antenna patterns deployed in each repeater with its coverage is presented as well.[8] Modeled receiver antenna height is 2 meters Above Ground Level (AGL).

For comparison purposes, the analysis used two propagation models: TIREM-EDX and Free Space + RMD. The TIREM-EDX (Terrain Integrated Rough Earth Model) is used by Sirius XM for its own site coverage and network planning, while the Free Space + RMD (Reflection plus multiple diffraction loss) is useful to predict the path loss in close-in line-of-sight environments. The TIREM-EDX model used in this analysis was calibrated by measuring the received signal power levels on streets and highways in the Las Vegas market.[9] As a result, the TIREM-EDX propagation model, with Las Vegas tuned ground clutter attenuations, provides a good estimate of signal levels expected on the street in Las Vegas from both the Sirius XM repeater network as well as from the various WCS network configurations.

Using these models of a simulated Las Vegas system, we analyzed system-wide WCS downlink interference impact. The interference levels that impact satellite radio reception are determined for the -55 dBm interference threshold level for interference originating from the 5 MHz C or D blocks.[10] The impact level for the interference originating from the 5 MHz A or B blocks is -44 dBm. Channel bonding (*i.e.*, operations over 10 MHz channels) would significantly worsen the interference conditions by lowering the tolerance levels by roughly 10 dB. Interference levels higher than these specified values would significantly impair satellite radio signal reception by muting audio streams that Sirius XM subscribers expect to receive with high quality of service.

For these two impact levels, we analyzed base station coverage for different average base station downlink transmit power levels as follows:

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[8] In this market, the XM repeater network has five locations compared to three locations for the Sirius repeater network.

[9] Sirius XM conducted drive testing in various markets to determine market signal availability.

[10] The Technical Appendix to Sirius XM's April 23, 2010 comments shows impact levels for mobile and fixed transmitter emissions in various WCS blocks. April 23, 2010 Technical Appendix at 5-7.

- 2000 W: Allowed in the current FCC rules for a 5 MHz WCS A or B block transmission. Alternatively, this power level could simulate a channel bonding operation with A and B block channels that would each transmit 1000 W. Alternatively, 2000 W can be assumed as a combined transmission from A, B and C blocks situated on the same or other nearby towers.[11]
- 1300 W
- 1000 W
- 500 W: Represents transmissions in a single 5 MHz WCS block, or a 10 MHz block at 250 W transmit power in each block.

B. Discussion of Results

Table 1 summarizes the coverage prediction analysis results for -44 and -55 dBm downlink signal levels using the above model. The analysis considers a 159 site cellular network deployment in Las Vegas spread over a 200 sq. km area. The model simulates base station downlink transmit power levels for this area with the propagation models described above, and presented for two antenna down tilt angles at 2° and 6°. In addition to Table 1, coverage plots are provided for selected cases in figures from 2 to 13.

From the 2000 W downlink power level analysis in Figures 2 and 3, almost the entire 200 sq. km area could be covered with power levels exceeding -55 dBm when there is line-of-sight between the base station antennae and the satellite radio receiver in typical driving conditions. Even with terrain effects, interference levels above -55 dBm are present in up to 74% of the analyzed area. The area covered with signal power levels higher than -44 dBm is more than 22% in the 200 sq. km area with down tilt angles at 2° and 6°.[12] Table 1 also addresses the 1300 W, 1000 W and 500 W cases, showing significant interference created by WCS downlink transmissions in each case.

The analysis shows significant interference, especially for the 10 MHz channel bonding cases—where there is an interference threshold of -55 dBm—in which the interference region does not reduce below 32% of the 200 sq. km area using any of the selected path loss models and antenna tilt angles.[13] Even for a 5 MHz A or B block channel with a -44 dBm interference threshold, the interference area would be roughly 7% of the 200 sq. km area, leading to significant service outages for satellite radio customers.[14]

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[11] The WCS Coalition indicated in its January 26, 2012 letter that WCS base stations would bond 5 MHz A and B blocks to create a 10 MHz channel. The current rules, permitting an average equivalent isotropically radiated power (EIRP) of up to 2,000 watts within any 5 MHz of authorized bandwidth, would allow a total of 4000 W downlink power level in the bonded A and B blocks, which is at least twice as high as the interference power levels analyzed in this paper. *See* 47 C.F.R. § 27.50(a)(1)(A).

[12] Table 1 shows that the transmit power level carries more weight in determining the final interference conditions than the transmit antenna down tilt angle for the analyzed cases.

[13] *See Table* 1, 500W EIRP, Terrain model, 6° downtilt: 25% + 7% = 32%.

[14] 7% area corresponds to 250 meter distance for a site with 1 Km radius.

Base station EIRP (W)	Ground Interference Level (dBm)	2° down tilt Line of sight model	2° down tilt Terrain model	6° down tilt Line of sight model	6° down tilt Terrain model
2000	**>= -44**	31%	22%	22%	18%
	-44 to -55	69%	52%	70%	40%
1300	**>= -44**	21%	16%	15%	14%
	-44 to -55	75%	45%	66%	34%
1000	**>= -44**	16%	13%	13%	12%
	-44 to -55	76%	42%	58%	32%
500	**>= -44**	7%	6%	8%	7%
	-44 to -55	63%	35%	40%	25%

Table 1: Percent of (200 Sq. Km) analyzed area where WCS downlink signal levels exceed the selected interference threshold levels.

Figures 12 and 13 present close-up views of an area covered by four WCS stations. As can be seen, most of the Las Vegas city center would be filled with power levels exceeding -55 dBm, and signal levels higher than -44 dBm would be present within a few blocks from the base station. Satellite radio consumers in slow or stopped traffic would be subjected to significant and frequent static downlink interference for extended periods of time by interference from all WCS blocks.

Additionally, in order to provide a real life example for LTE network coverage and to compare to the predictions made in this paper, we measured an actual LTE base station coverage distance for -55 dBm. The selected site is located near the Trenton Mercer Airport in West Trenton, New Jersey, at the intersection of Bear Tavern Road and Highway I-95, serving the heavy traffic corridor between Philadelphia, Trenton, and Princeton. This site operates in the 700 MHz band with a 10 MHz FDD LTE channel. Ground power levels were measured at locations up to 2 km away from the site. Figure 14 shows the field test results with red dots showing the locations with measured signal levels exceeding -55 dBm at up to 775 meters away from the site. A coverage prediction was made based upon the field test data to calibrate the model to predict the extent of interference in the surrounding area. Figure 15 shows the prediction results in red shaded area where the signal levels would exceed -55 dBm.[15] As shown here, excessive interference would occur not only on the tested highway locations but also on secondary and residential roadways with line of sight to the tower. Although these measurements are based on operations in a different frequency band, this real-world example demonstrates that the dead zones created by excessive interference to satellite radio service can occupy large portions of similar base station coverage areas. Also, considering that WCS will need a dense chain of base stations to

[15] In the coverage prediction, the base station was modeled with a 3 sector antenna setup where each antenna was located at 50 ft AGL. The coverage was plotted for the Free Space + RMD (Reflection plus multiple diffraction loss) propagation model for a receiver antenna at 2 meters AGL.

cover major roads, such interference would be repeated frequently causing major impact to satellite radio service.

Figures 16 and 17 show XM's five repeater locations and their coverage in Las Vegas. Sirius XM has previously demonstrated that repeater signal levels higher than -60 dBm can effectively mitigate WCS interference.[16] However, this level of coverage is available only at a relatively small area near a repeater as shown in Figure 16.

III. <u>Conclusions</u>

The WCS Coalition January 26 Letter used a dense base station deployment to model the uplink interference potential. However, this example also accentuates Sirius XM's concerns about the magnitude of downlink interference that could occur from such deployments under current WCS rules.

This paper analyzed downlink interference potentials using a representative cellular network model similar to the one that NextWave provided in 2007 for a proposed network deployment in Las Vegas, Nevada. As illustrated by the deployment example used here, the footprint of a cellular-type network will be significantly greater than Sirius XM repeater network's capability to help mitigate any WCS interference.

These examples demonstrate that WCS downlink interference could cover significant portions of the 200 sq. km market around Las Vegas. Even at the lowest simulated downlink power levels, interference could extend several city blocks from a base station. A cellular network deployed in the WCS band with the current Part 27 emission rules would therefore be likely to cause significant interference to satellite radio reception across a widespread area.

The downlink signal level measurements from an actual LTE cellular network in New Jersey confirmed the significant interference impact found in our evaluation of the simulated WCS network deployment in Las Vegas, with actual measured power levels above -55 dBm extending up to 775 meters away from the base station that might only have a 1 km coverage radius.

These large interference ranges, coupled with sequential deployment of WCS base stations on commuter roads, would create significant interference and signal outages for satellite radio customers. Such adverse conditions could be eliminated with the use of proper ground power flux density limits.

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[16] Reply Comments of Sirius Satellite Radio, Inc., Exhibit C at 8, WT Docket No. 07-293, IB Docket No. 95-91, Gen. Docket No. 90-357, RM No. 8610 (filed March 17, 2008)

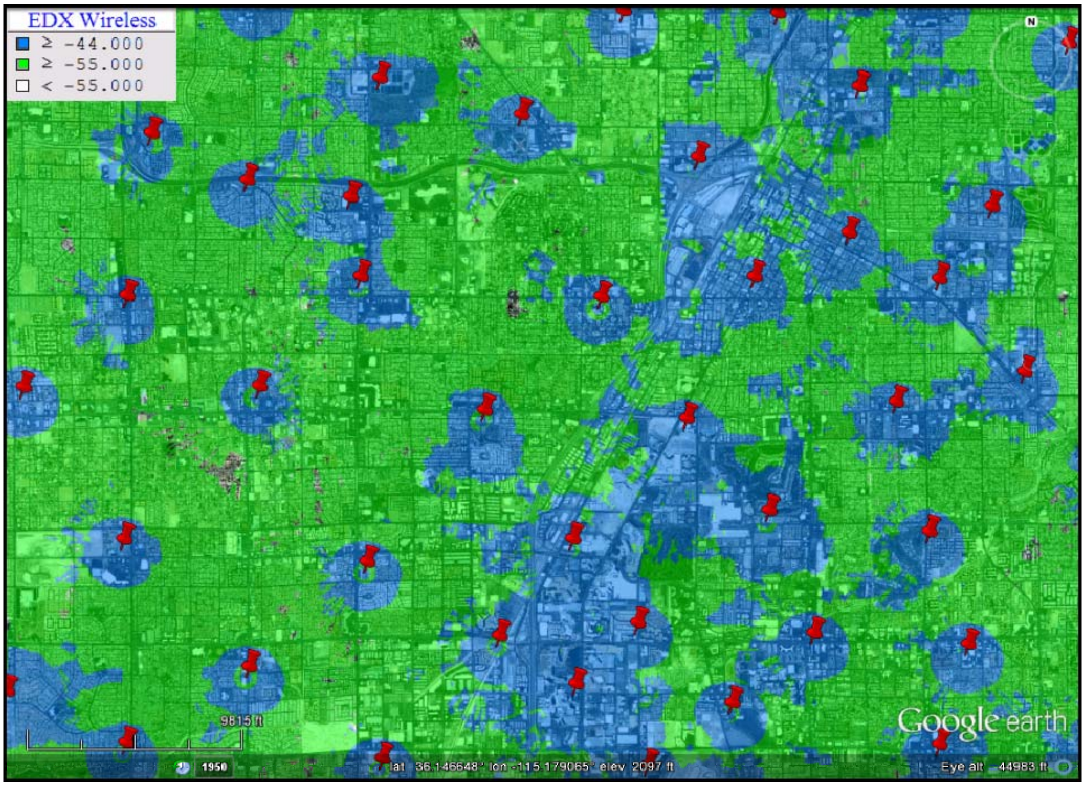

Figure 2: Free space + RMD coverage (dBm) for a 2000 W site with 2° down tilt.

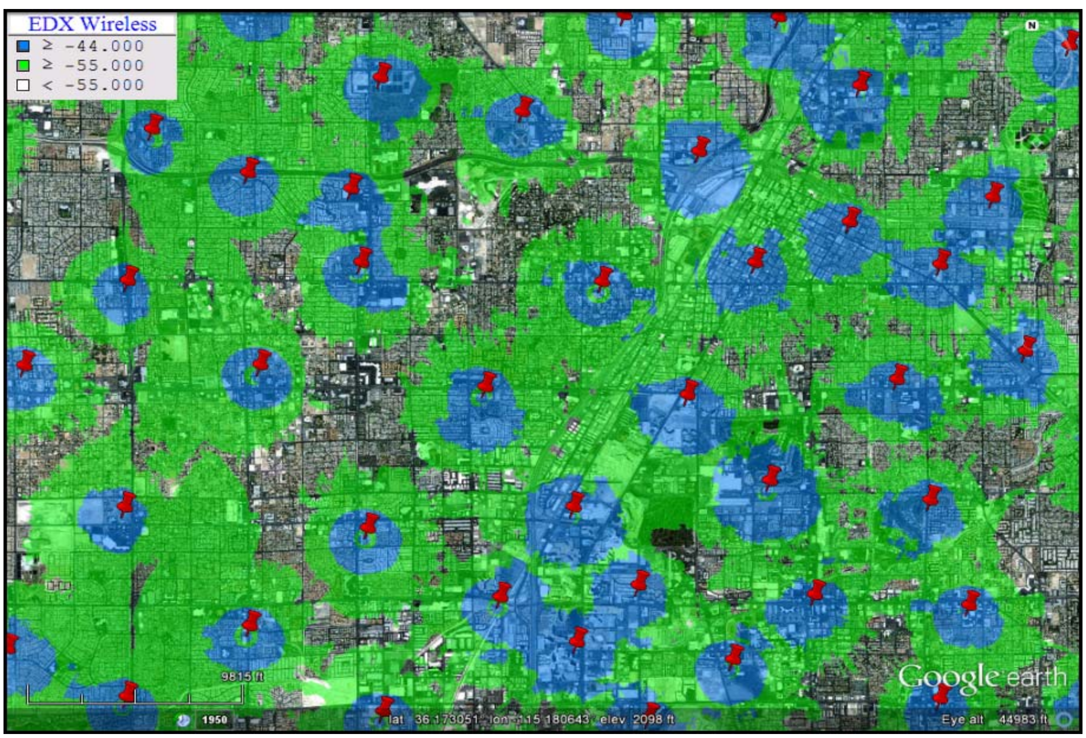

Figure 3: TIREM EDX coverage (dBm) for a 2000 W site with 2° down tilt.

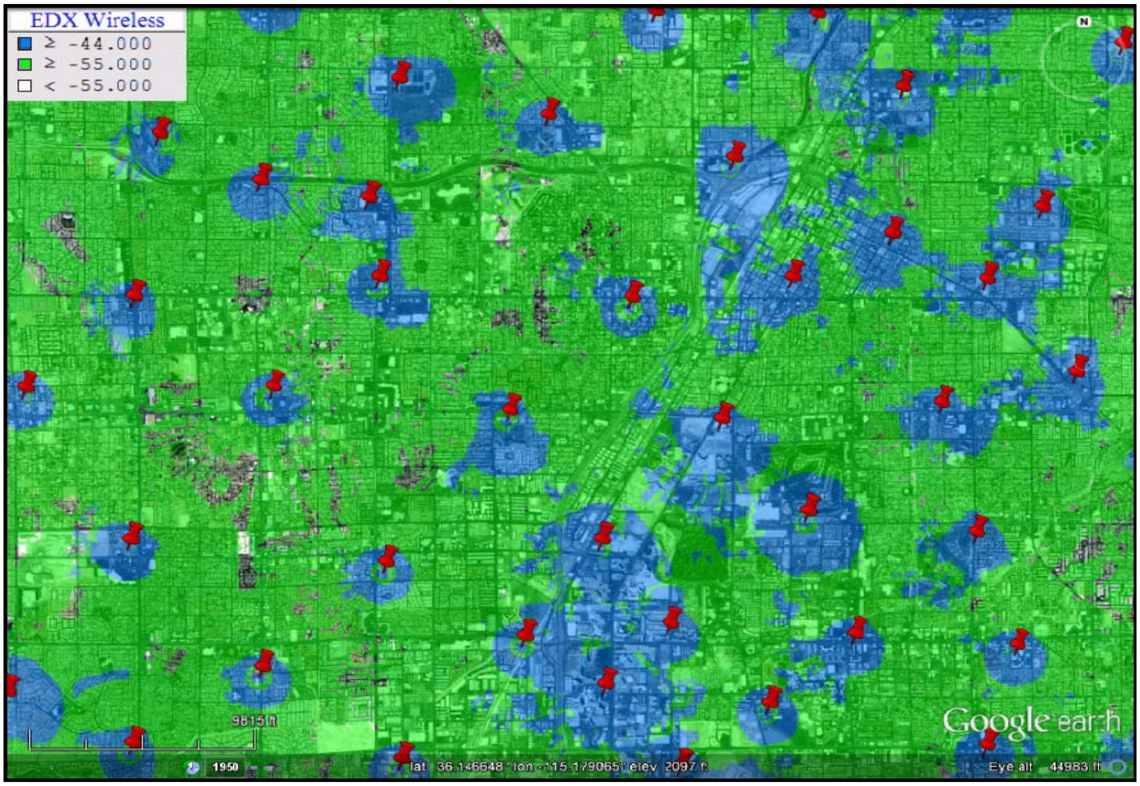

Figure 4: Free space + RMD coverage (dBm) for a 1300 W site with 2° down tilt.

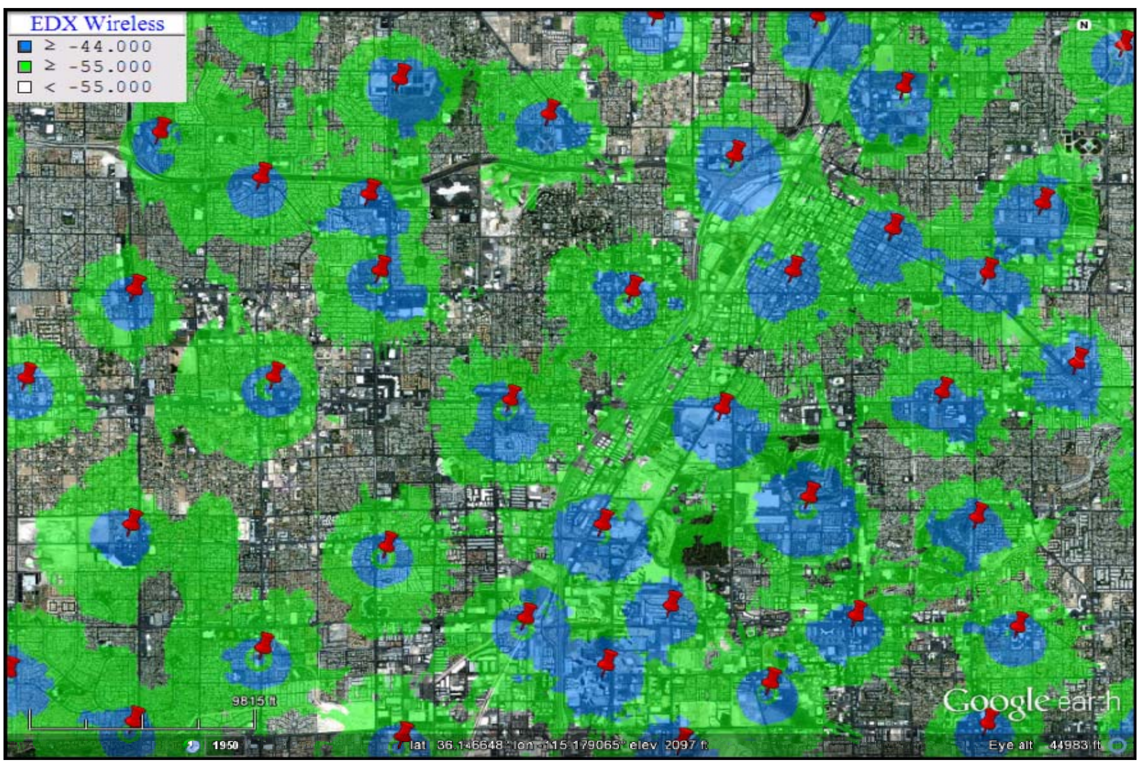

Figure 5: TIREM EDX coverage (dBm) for a 1300 W site with 2° down tilt.

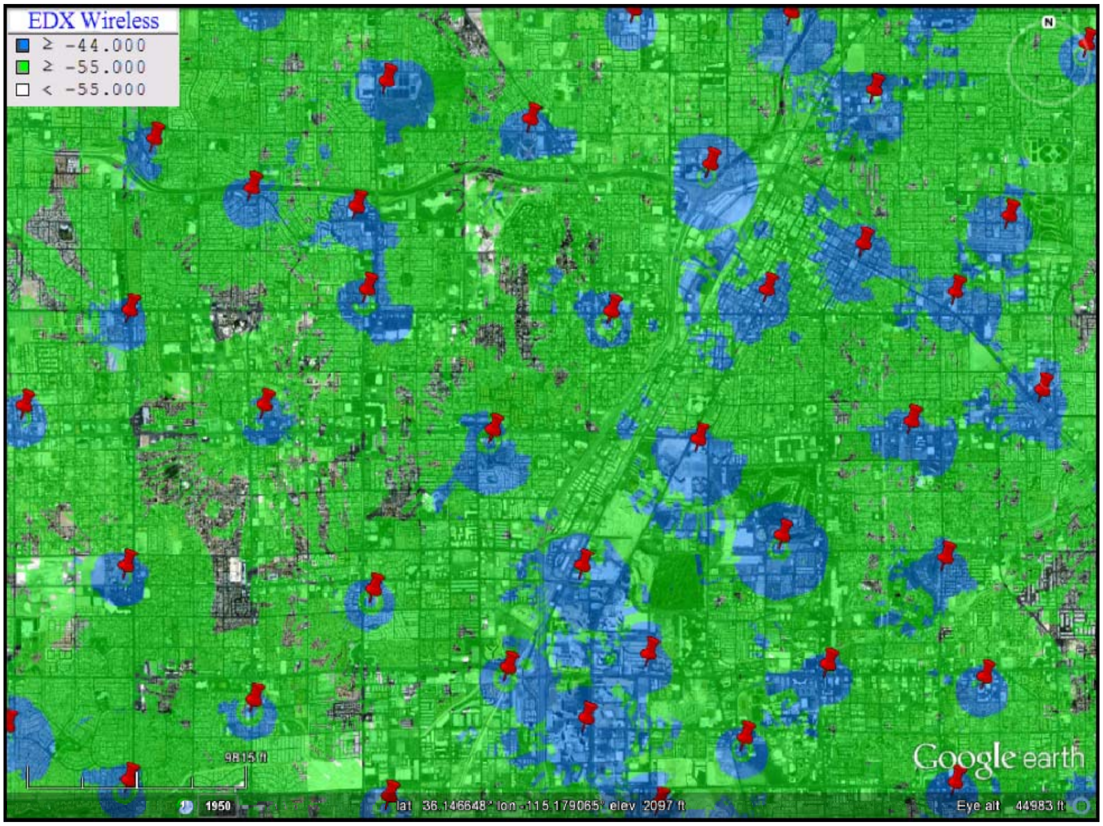

Figure 6: Free space + RMD coverage (dBm) for a 1000 W site with 2° down tilt.

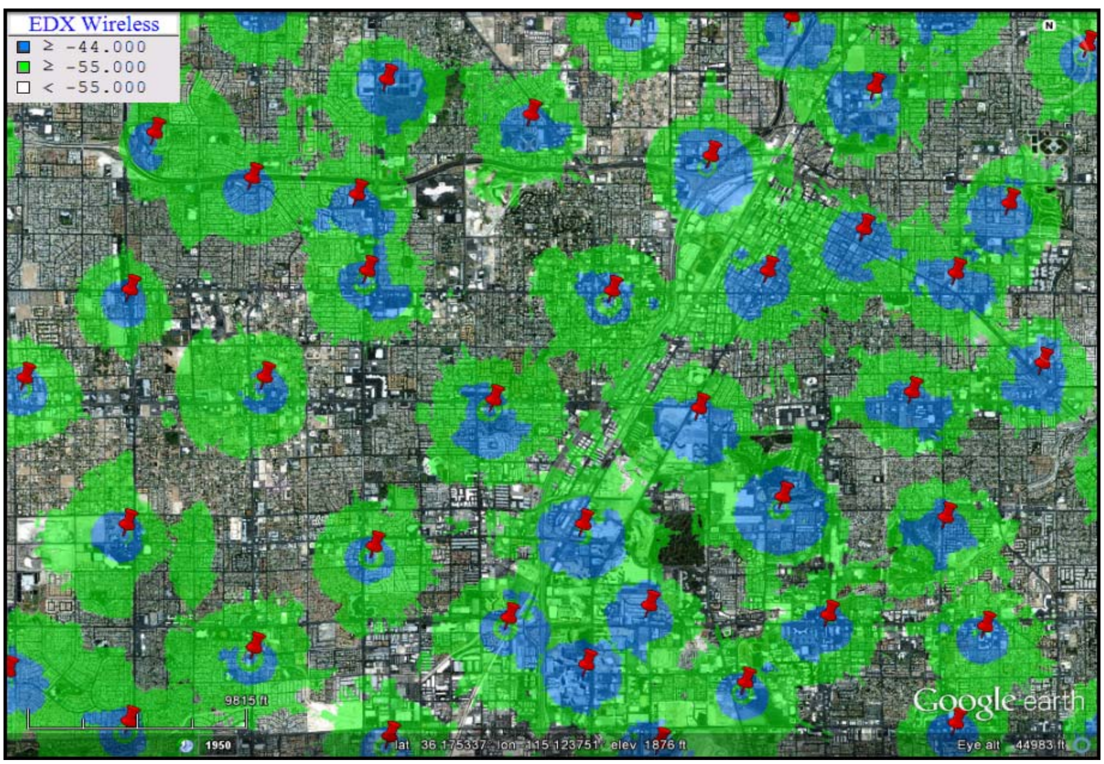

Figure 7: TIREM EDX coverage (dBm) for a 1000 W site with 2° down tilt.

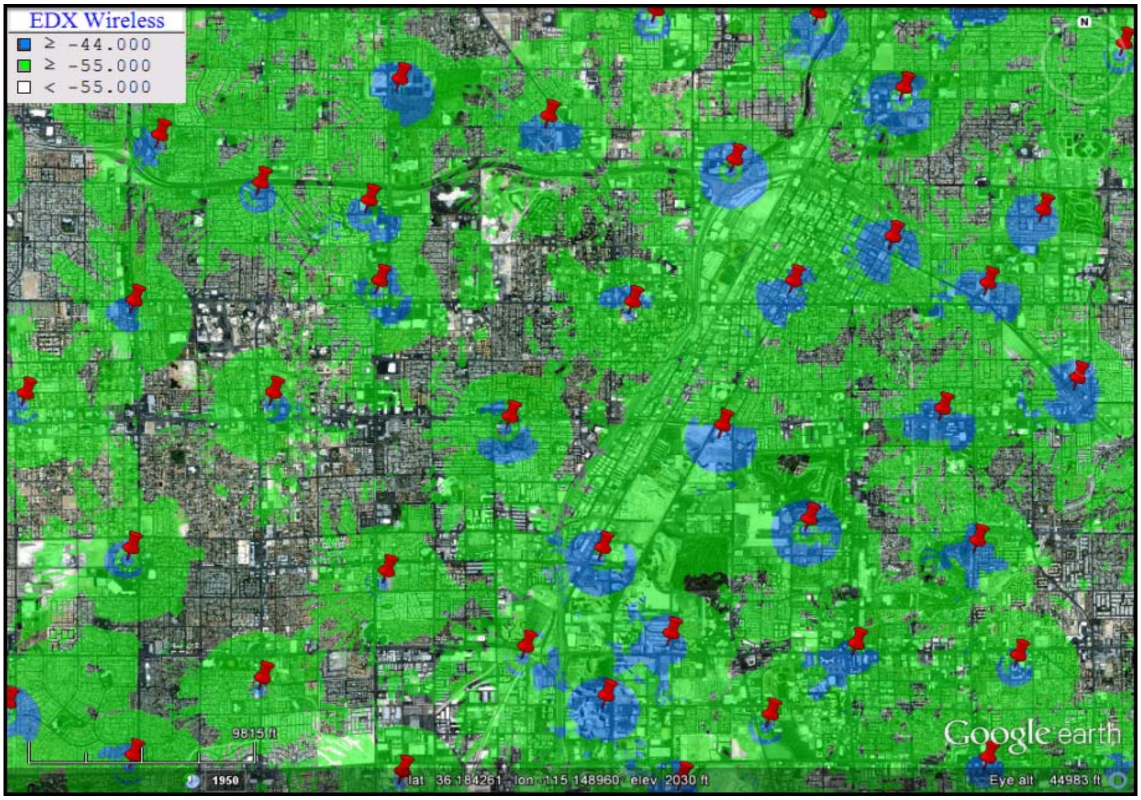

Figure 8: Free space + RMD coverage (dBm) for a 500 W site with 2° down tilt.

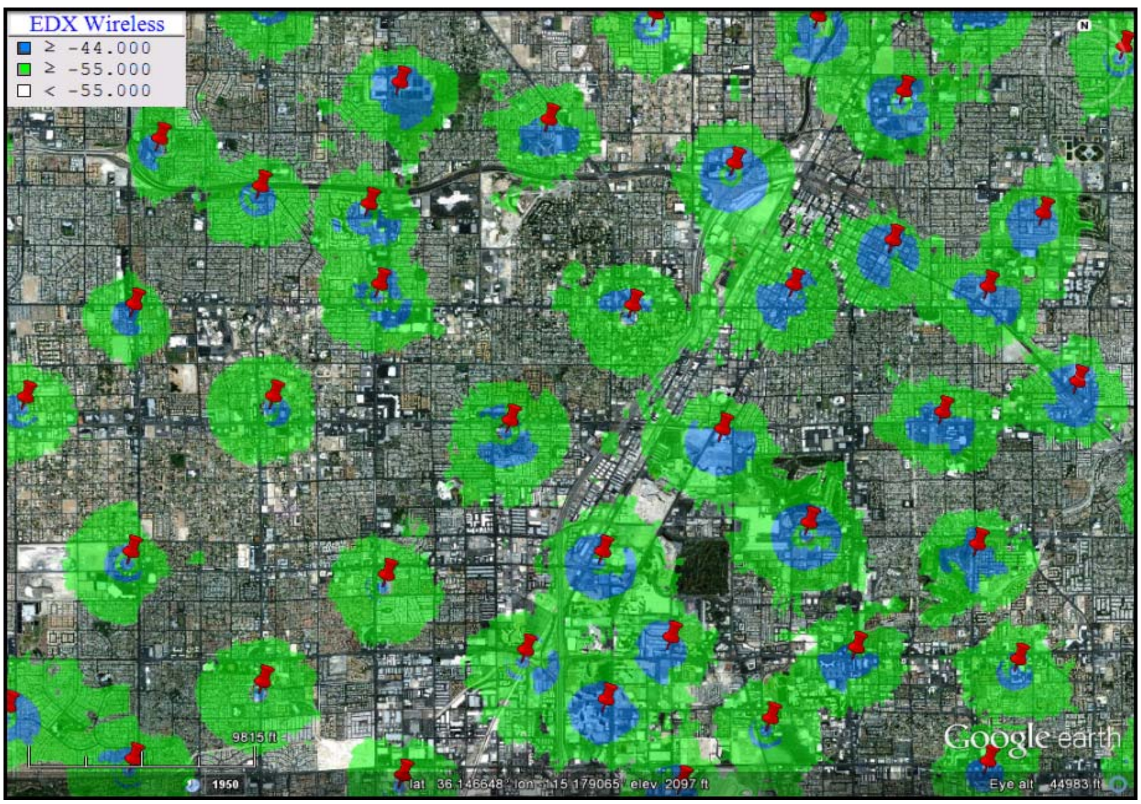

Figure 9: TIREM EDX coverage (dBm) for a 500 W site with 2° down tilt.

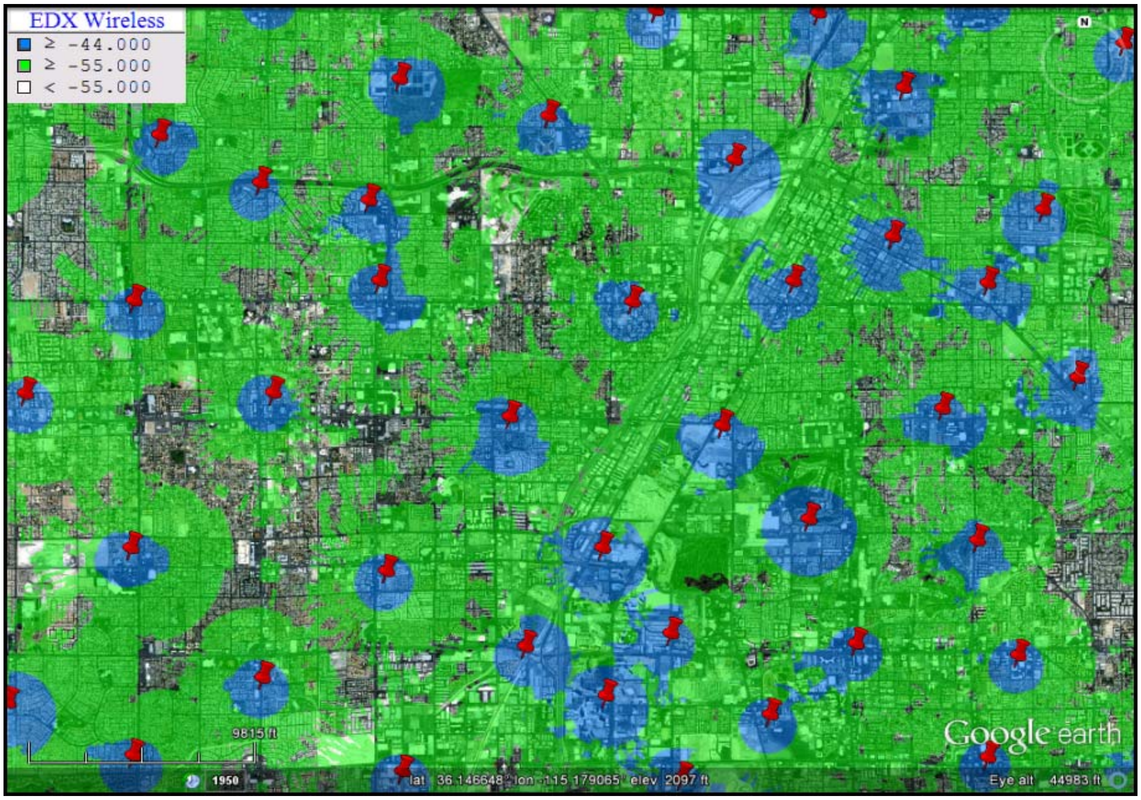

Figure 10: Free space + RMD coverage (dBm) for a 1300 W site with 6° down tilt.

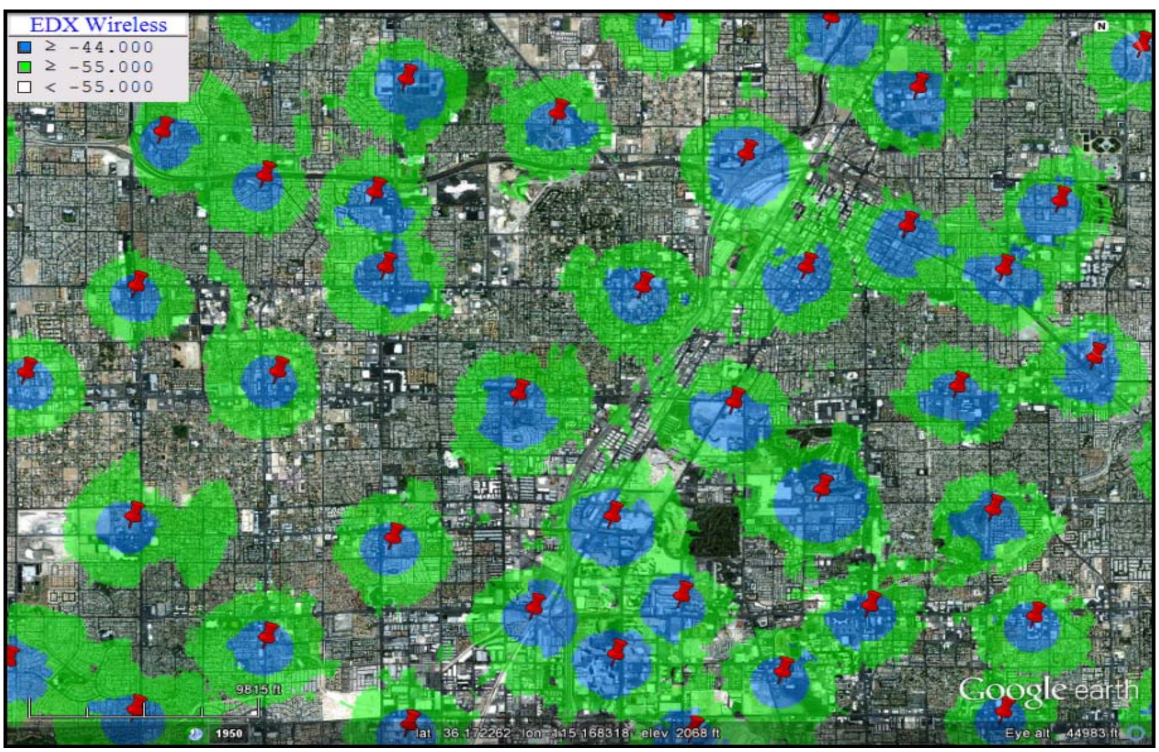

Figure 11: TIREM EDX coverage (dBm) for a 1300 W site with 6° down tilt.

Figure 12: Free space + RMD coverage (dBm) for a 1300 W site with 2° down tilt.

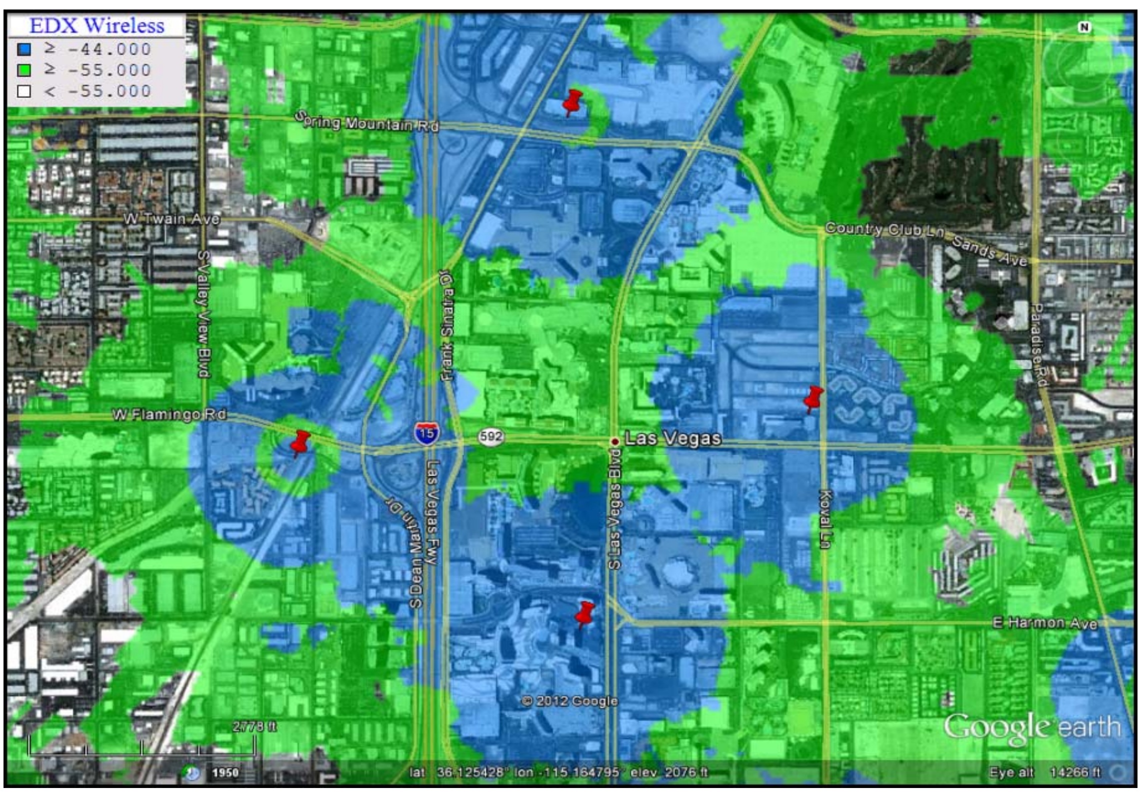

Figure 13: TIREM EDX coverage (dBm) for a 1300 W site with 2° down tilt.

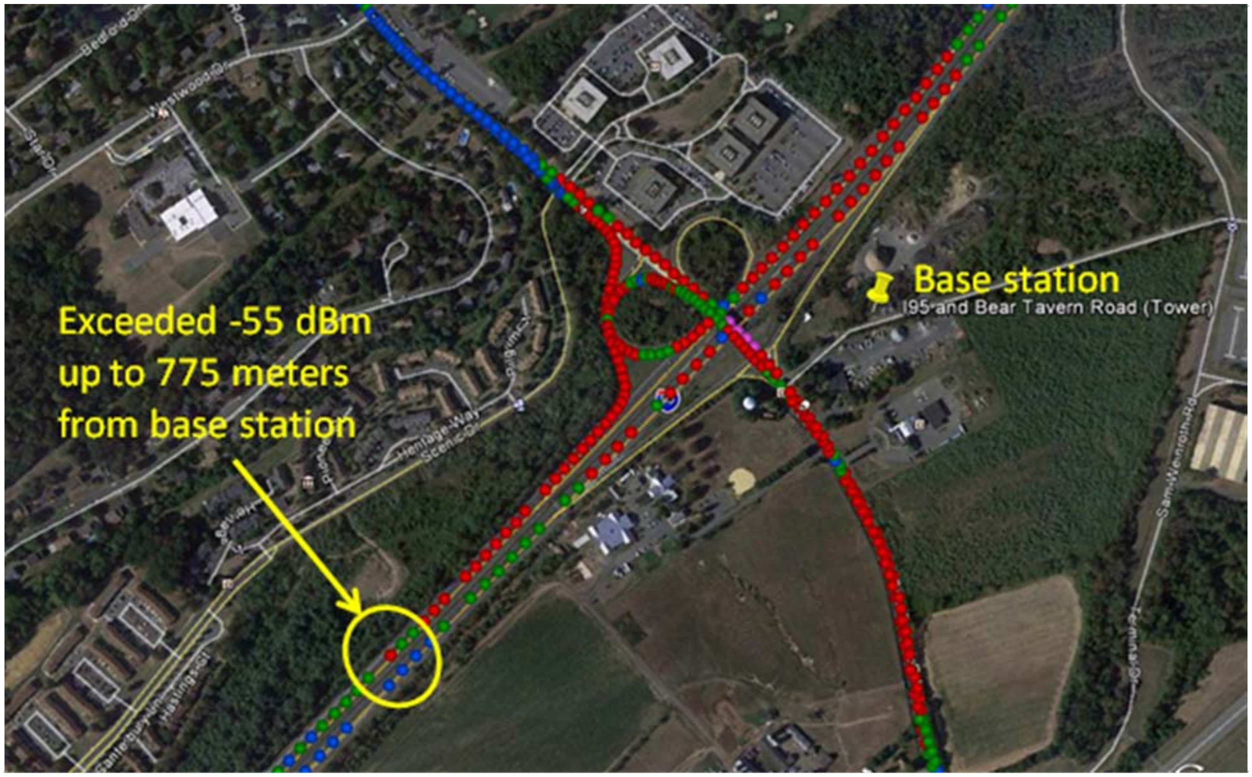

Figure 14: Red dots show the locations with measured downlink power levels exceeding -55 dBm.

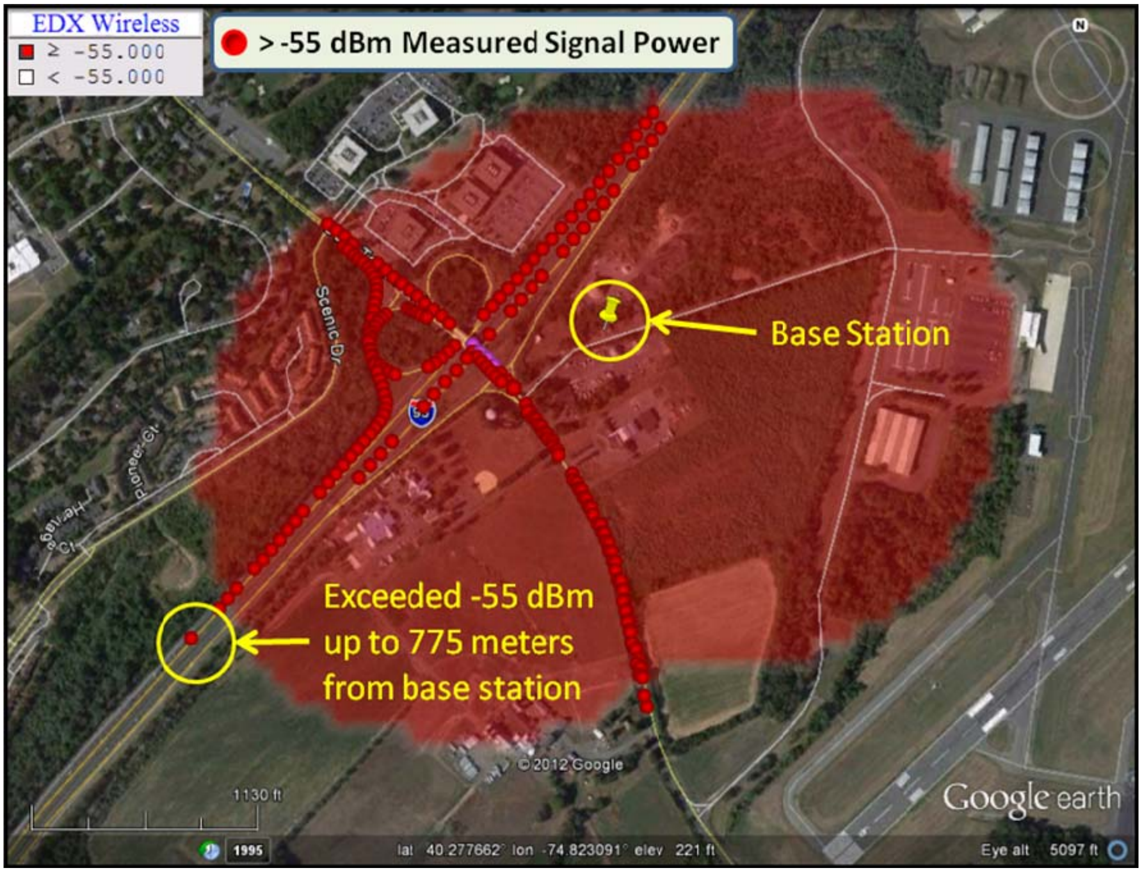

Figure 15: The red shaded area shows the coverage prediction down to -55 dBm downlink power level.

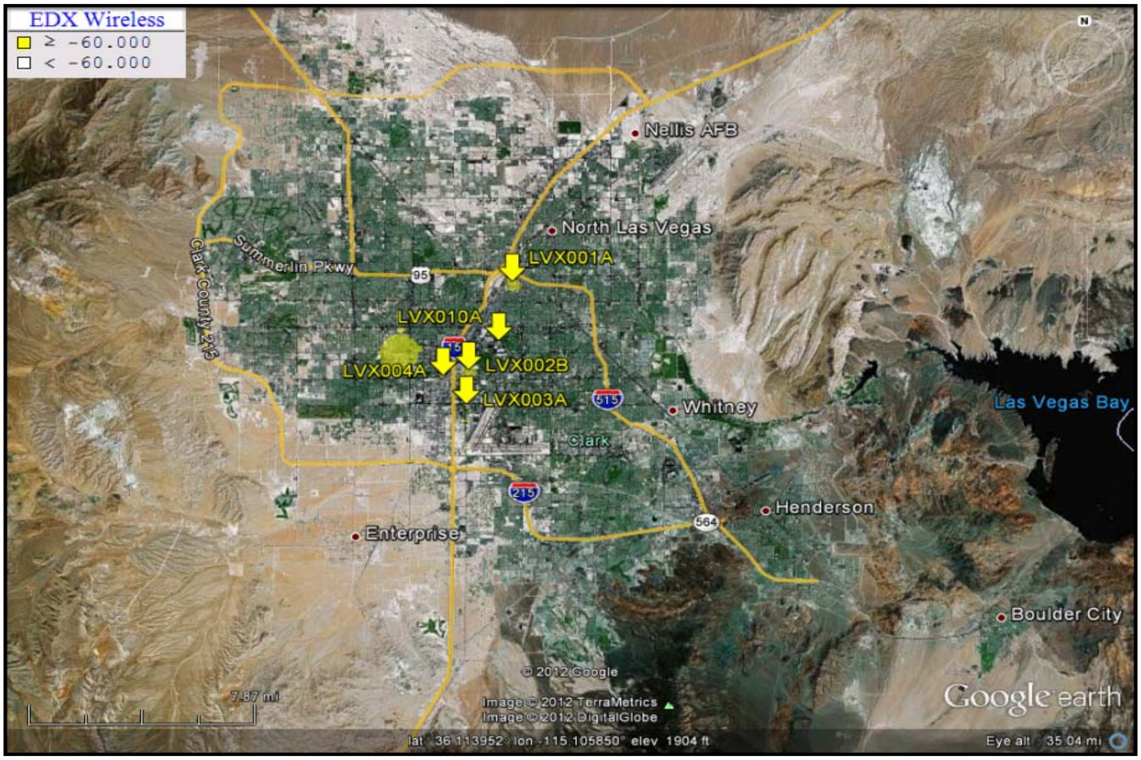

Figure 16: Sirius XM repeater coverage area with signal levels are higher than -60 dBm that can help mitigate WCS interference in the Las Vegas Market (modeled with TIREM EDX). Yellow arrows show the Sirius XM repeater site locations. Yellow areas show the extent of repeater signal levels >-60 dBm.

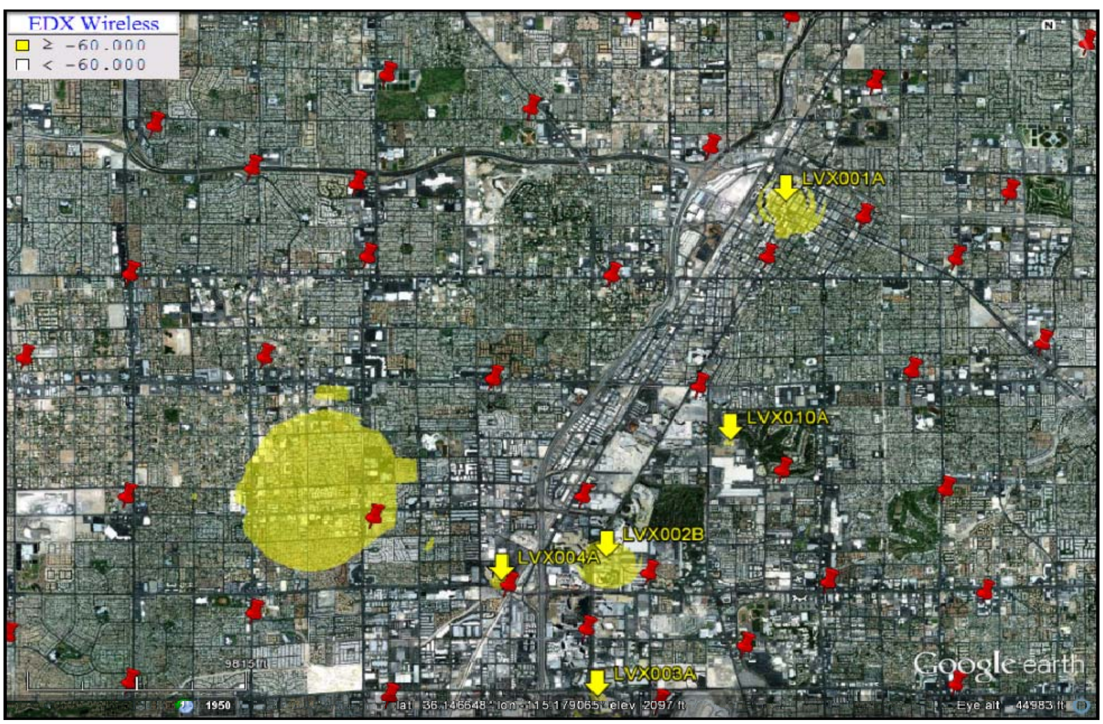

Figure 17: Close in version of Figure 16. Red pins show the WCS site locations vs. Sirius XM coverage that could help mitigate interference.